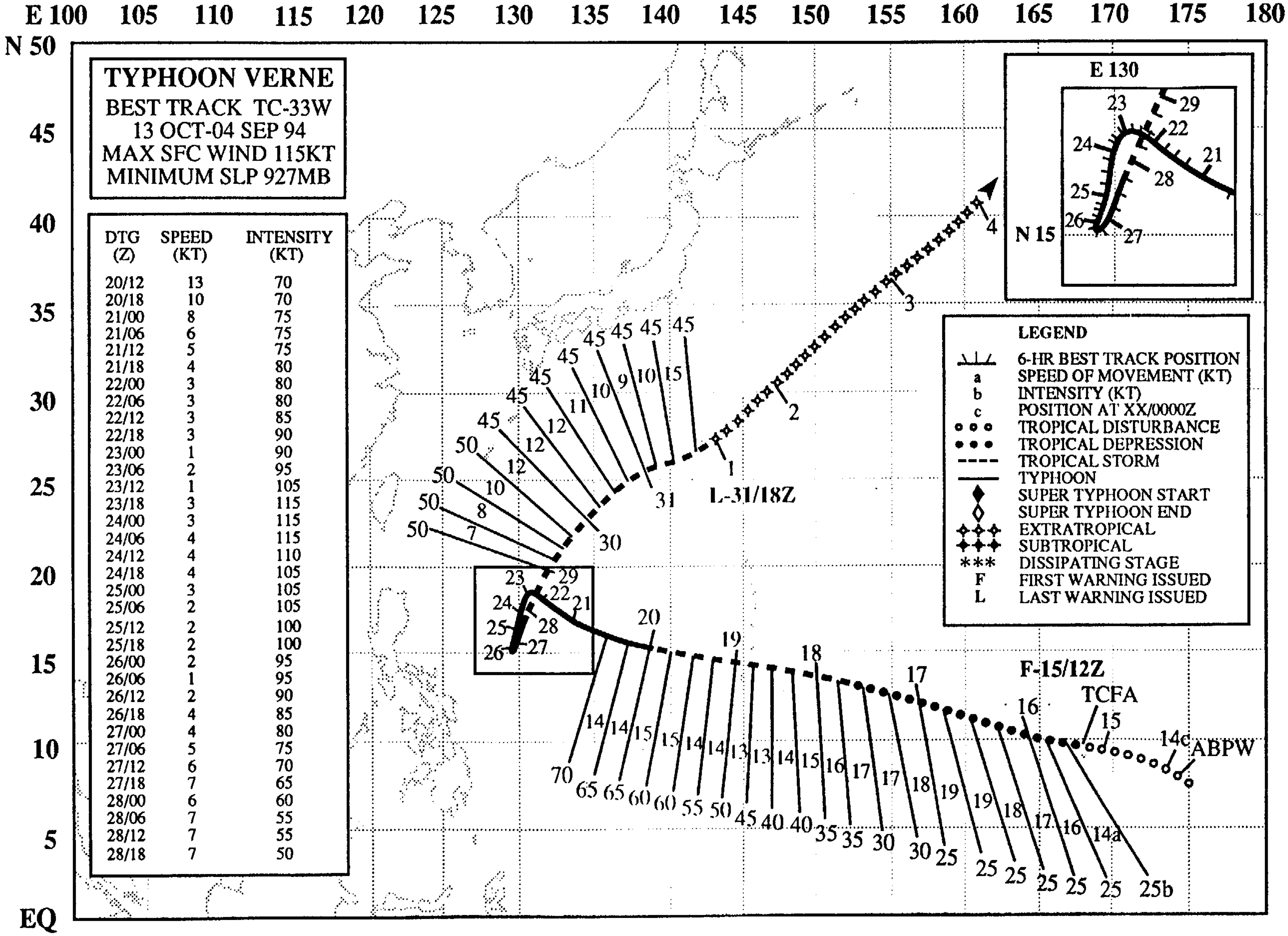


| DTG (Z) | SPEED (KT) | INTENSITY (KT) |
|---|---|---|
| 20/12 | 13 | 70 |
| 20/18 | 10 | 70 |
| 21/00 | 8 | 75 |
| 21/06 | 6 | 75 |
| 21/12 | 5 | 75 |
| 21/18 | 4 | 80 |
| 22/00 | 3 | 80 |
| 22/06 | 3 | 80 |
| 22/12 | 3 | 85 |
| 22/18 | 3 | 90 |
| 23/00 | 1 | 90 |
| 23/06 | 2 | 95 |
| 23/12 | 1 | 105 |
| 23/18 | 3 | 115 |
| 24/00 | 3 | 115 |
| 24/06 | 4 | 115 |
| 24/12 | 4 | 110 |
| 24/18 | 4 | 105 |
| 25/00 | 3 | 105 |
| 25/06 | 2 | 105 |
| 25/12 | 2 | 100 |
| 25/18 | 2 | 100 |
| 26/00 | 2 | 95 |
| 26/06 | 1 | 95 |
| 26/12 | 2 | 90 |
| 26/18 | 4 | 85 |
| 27/00 | 4 | 80 |
| 27/06 | 5 | 75 |
| 27/12 | 6 | 70 |
| 27/18 | 7 | 65 |
| 28/00 | 6 | 60 |
| 28/06 | 7 | 55 |
| 28/12 | 7 | 55 |
| 28/18 | 7 | 50 |

# TYPHOON VERNE (33W)

## I. HIGHLIGHTS

Typhoon Verne was a relatively long-lived tropical cyclone that passed within range of Guam's NEXRAD. Several special cross-sections of reflectivity and radial velocity were obtained through Verne's center and peripheral cloud bands. Verne underwent unusual motion in the Philippine Sea: for over seven days it meandered within 150 nm (280 km) of 17°N ; 130°E.

## II. TRACK AND INTENSITY

During the first week of October, the deep tropics of the western North Pacific became inactive (Figure 3-33-1a). Higher-than-normal pressure accompanied a reduction in deep convection. By mid-October, deep convection began to increase in low latitudes, especially east of 140°E, and an active monsoon trough formed along about 10°N (Figure 3-33-1b). By the third week of October, this monsoon trough evolved into a chain of four tropical cyclones: Teresa (34W), Verne, Wilda (35W), and Yuri (36W) (Figure 3-33-1c).

The tropical disturbance that became Verne was first mentioned on the 131800Z October Significant Tropical Weather Advisory when an area of deep convection associated with a broad low-level cyclonic circulation formed in the Marshall Islands. At 150800Z, a Tropical Cyclone Formation Alert was issued when this disturbance showed signs of increased organization. Continued improvement in the convective banding features prompted the first warning at 151200Z. Tropical Depression 33W moved west-northwestward along the axis of the monsoon trough, and its intensification rate remained slow. At 171800Z Tropical Depression 33W was upgraded to Tropical Storm Verne. Continuing on a steady west-northwestward track, Verne passed 50 nm north of Guam during the early morning hours of October 19. Verne acquired a CDO and its estimated intensity was 50 kt (26 m/sec). At 200000Z Verne was upgraded to a typhoon based upon intensity estimates from satellite imagery. Verne continued on a steady west-northwestward track until 210600Z when it abruptly slowed. It then meandered within 150 nm of 17°N ; 130°E for seven days. Verne reached a peak intensity of 115 kt (59 m/sec) at 231800Z while moving slowly southward in the Philippine Sea (Figure 3-33-2). After Verne turned northward at 260600Z, it steadily weakened, and by 280600Z it had dropped below typhoon intensity. The final warning was issued at 010000Z November as Verne recurved east of Japan and became extratropical.

## III. DISCUSSION

### a. NEXRAD's view of Verne

Verne's closest point of approach to Guam was 50 nm (90 km) to the north at 180000Z. In addition to Verne's CDO, peripheral cloud bands tracked well-within the 124 nm (230 km) range of the NEXRAD's Doppler velocity sensor. Many radar products were examined, including: the base reflectivity, the base velocity, animation of the base reflectivity, convective cell tracking, and the one- and three-hour integrated precipitation products.

#### 1. STORM-TOTAL PRECIPITATION

For almost two days (180420Z to 200030Z), Guam's NEXRAD provided a continuous integration of the precipitation associated with Verne (Figure 3-33-3). NEXRAD-estimated rainfall of over one inch fell in a 120 nm (220 km)-wide swath along Verne's track. Maximum estimated storm-total rainfall values of four to six inches occurred in a narrower swath. The NEXRAD underestimated storm-total pre-

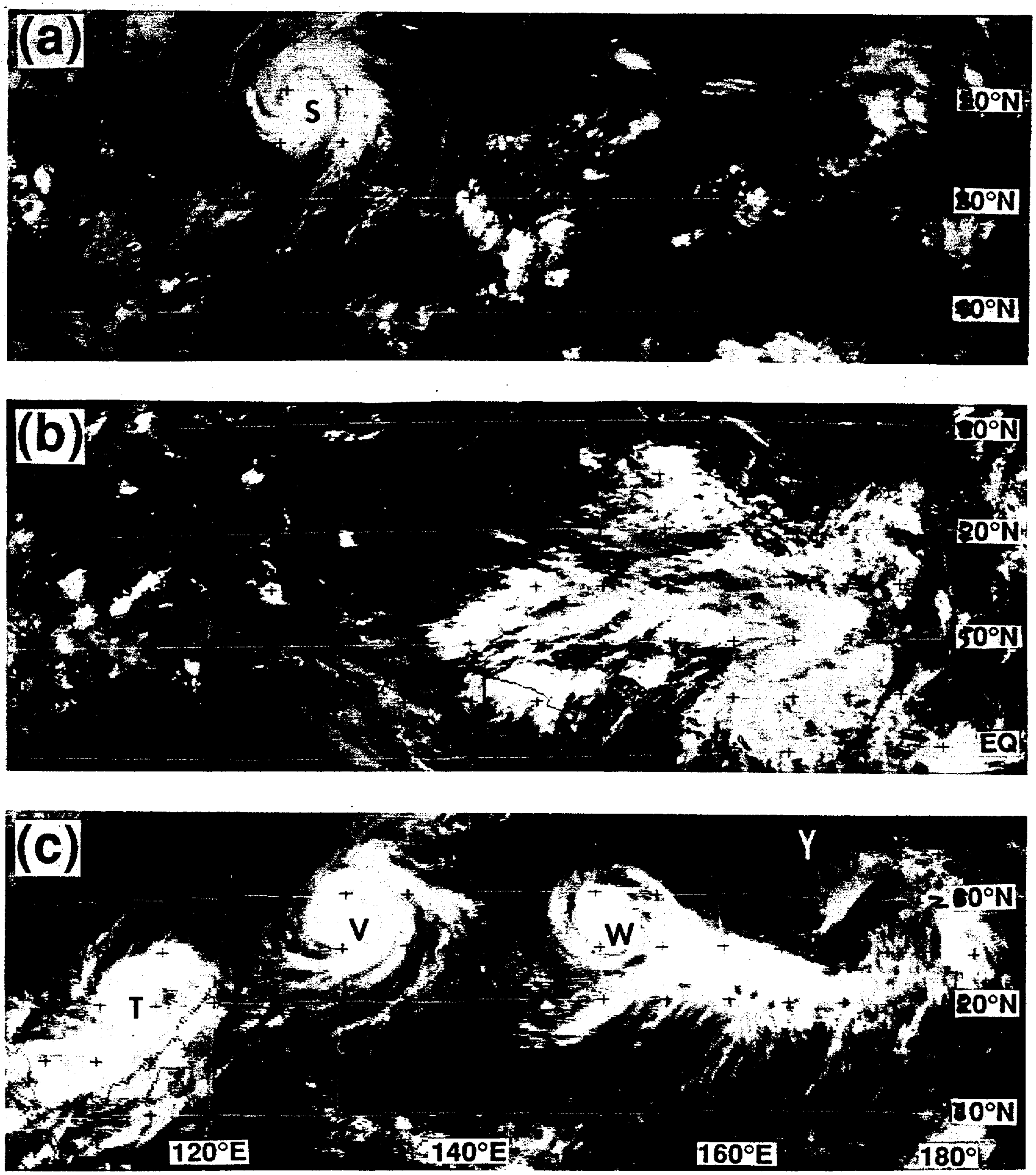


**Figure 3-33-1** Evolution of the large-scale distribution of deep convection in the western North Pacific during October. (a Things are very quiet in the tropics as Seth (S) moves out of the region (080031Z October infrared GMS imagery). (b) An increase in the amount of deep convection accompanies near-equatorial westerlies east of 140°E (140031Z October infrared GMS imagery). (c) Four named tropical cyclones — T = Teresa (34W), V = Verne, W = Wilda (35W) and Y = Yuri (36W) — are lined up WSW-ENE across the western North Pacific basin (230531Z October infrared GMS imagery).

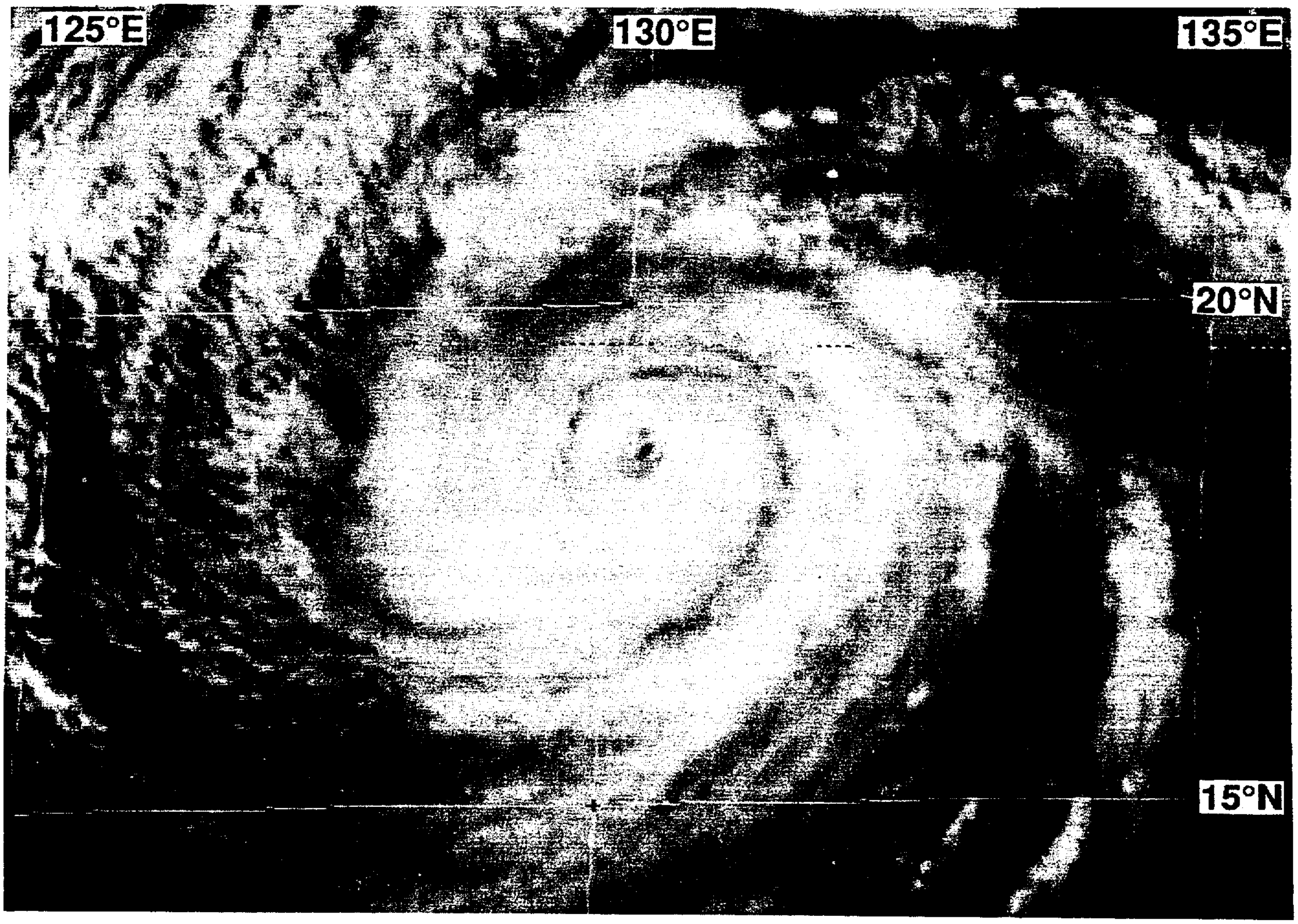


**Figure 3-33-2** Verne's eye is becoming better defined as it nears its peak intensity (230424Z October visible GMS imagery).

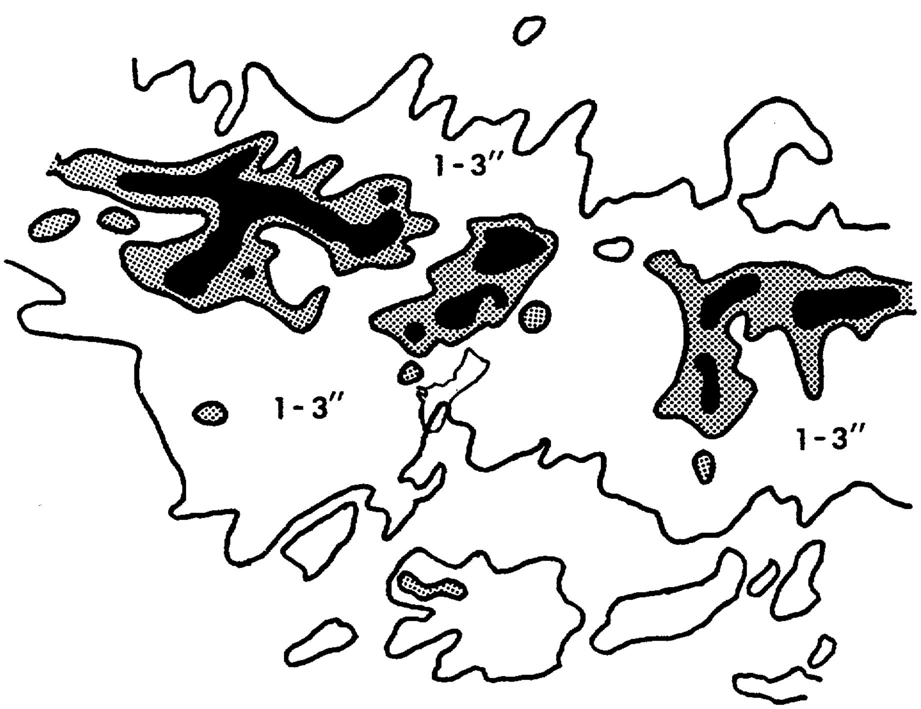


Figure 3-33-3 Estimated precipitation deposited by Verne as it tracked north of Guam (NEXRAD storm-total precipitation algorithm for the period 180420Z to 200030Z October). Outer contour = 1", shaded region received between 3" and 4", black regions received 4" or more.

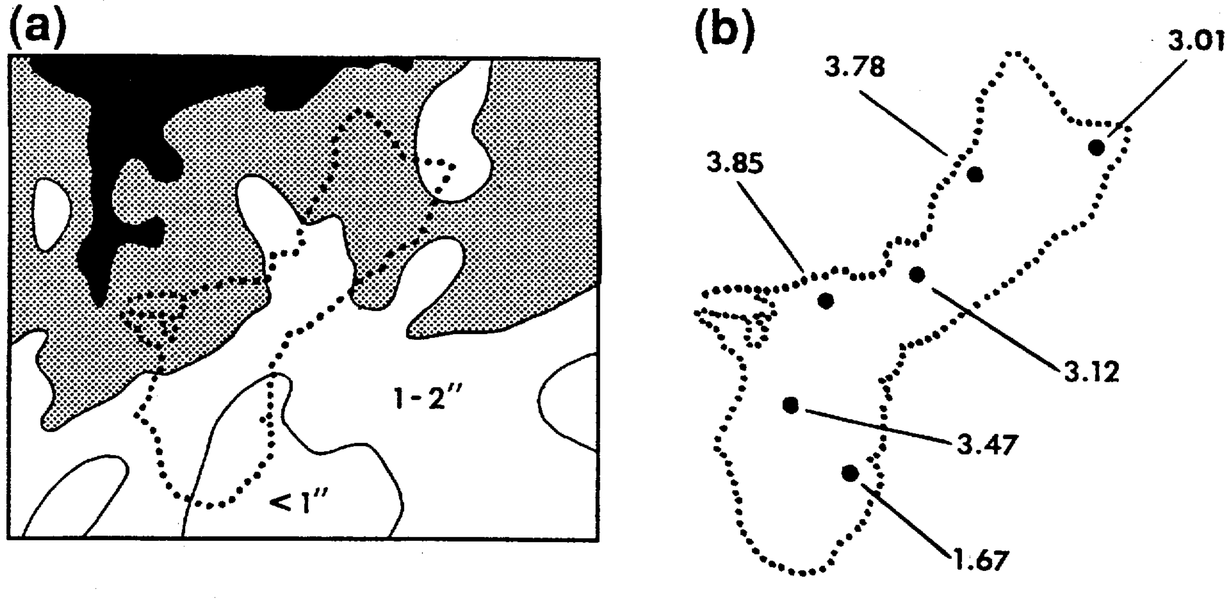


**Figure 3-33-4** (a) Enlargement of the Guam region showing NEXRAD storm-total precipitation during Verne. Outer contour = 1", shaded region received between 2" and 3", black region received 3" or more. (b) Storm-total precipitation during Verne measured on Guam.

cipitation by 33% to 50% when compared to rainfall measured on Guam (Figure 3-33-4a,b). In almost all heavy rain events on Guam for which NEXRAD storm-total precipitation estimates were available for comparison to actual observations from around the island, the NEXRAD estimates are short by 25%-50% of the measured values. Despite these under-estimations, the rainfall distribution shown by NEXRAD has agreed quite well with the observed distribution.

2. PATTERN AND EVOLUTION OF THE WIND AND DEEP CONVECTION

When Verne passed to the north of Guam, it was a tropical storm with a satellite intensity estimate of 50 kt (26 m/sec). Its satellite-observed structure was a CDO pattern with a banding feature (Figure 3-33-5). The thick cirrus canopy of Verne's CDO in early morning, low-sun-angle, visible satellite imagery (not shown) was seen to have an overshooting convective tower embedded in rather featureless dense cirrus. The dense cirrus obscured highly organized lower-level cloud structures as observed by the NEXRAD. The base reflectivity, vertical cross-sections through Verne's core, and the echo-top product obtained from Guam's NEXRAD showed that Verne was composed of a central arc of deep convection wrapping roughly half-way around the southeastern semi-circle of Verne's cloud-free center. This deep convection rose to at least 60,000 ft (18 km) in one convective cell (i.e., hot tower) on the eastern side of Verne's inner core (Figure 3-33-6). This convective hot tower was not steady-state, but was observed to go through three episodes of intense build-up followed by a period of weakening. With each pulse of the central hot tower, the inner-core convection became more organized and nearly formed an eye wall. As the hot tower weakened, the curvature of the inner-core convection lessened. In synchrony with the pulses of the inner-core hot tower, the reflectivity in the nearest rainband to the south of the inner core intensified, then subsided.

Even the wind structure of Verne's inner core was affected by the pulsing of Verne's central hot tower. Prior to a major pulse of the hot tower when Verne was near its closest point of approach to

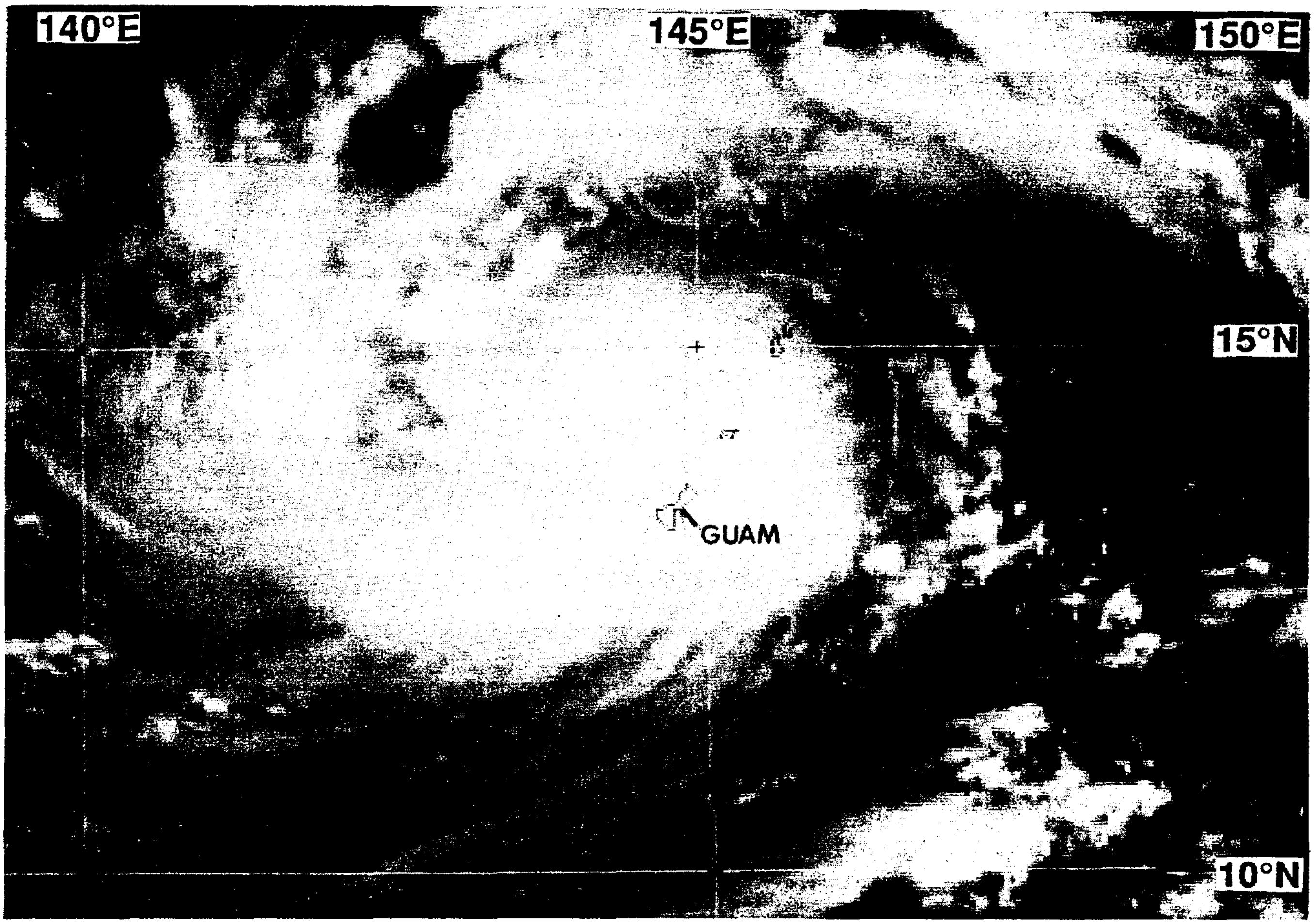


**Figure 3-33-5** Verne near its closest point of approach to Guam. Verne's CDO obscures its low-level center (182331Z October visible GMS imagery).

Guam, the NEXRAD-observed wind speed on a vertical slice cut east-west through Verne's center showed the text-book signature of a low-level cyclone overlain by an upper-level anticyclone. When the hot tower became very active, the wind on the same slice cut through Verne's core showed that in the hot tower, the outbound southerlies were carried upward throughout the column (Figure 3-33-7). Another feature of the vertical structure of the wind in Figure 3-33-7, is that the maximum low-level winds (both inbound and outbound) were at 4,000 ft (1.2 km), which was the lowest elevation observable by the radar at this range.

b. Unusual motion

Verne continued on a steady west-northwestward track until 210600Z when it abruptly slowed and then meandered within 150 nm (275 km) of 17°N ; 130°E for seven days. In finer detail, Verne's motion during this period consisted of a slow westward drift between 210600Z to 230000Z, a slow southward drift between 230000Z to 260600Z, and a turn to the north-northeast after 260600Z. Later, shortly before 281200Z, Verne began a modest acceleration toward the north-northeast. Verne's period of unusual motion began when the monsoon trough axis acquired a reverse orientation (see Figure 3-33-1c). At this time, 500 mb heights became higher in the ridge axis southeast of the trough than in the ridge axis to the north of the trough. Additionally, strong low-level northeasterly winds persisted over

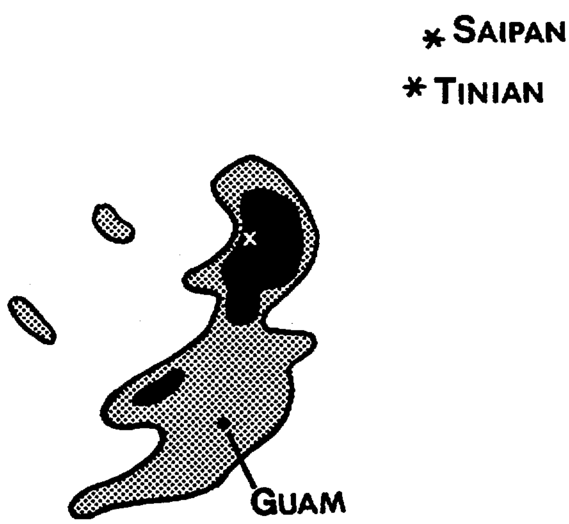


**Figure 3-33-6** Echo tops as seen by Guam's NEXRAD at 182318Z showing Verne's lone "hot tower" on the southeastern side of its inner core. Outer contour = 35,000 ft, black shaded region shows tops over 40,000 ft. Maximum top at this time was 56,000 ft. Small "x" denotes estimated location of Verne's low-level circulation center.

the western half of the Philippine Sea and the South China Sea. It is likely that these two environmental factors combined to cause Verne to stall.

c. Air-sea interactions

It has long been known that tropical cyclones leave a trail of reduced sea surface temperature (SST) across the ocean surface. This cooling, which can reach 6°C and may persist for several weeks, is predominantly caused by turbulent mixing which deepens the oceanic mixed layer (Kepert 1993). Modeling and observational studies show the bulk of the cooling occurs to the right of the track in the northern hemisphere (Price 1981, Holland 1987). One might expect that the cooling of the SST by a tropical cyclone might alter the horizontal and vertical structure of the atmospheric boundary layer in such a way so as to affect the intensity, structure and behavior of the tropical cyclone itself. In coupled air-sea models (e.g., Kurihara 1992), the maximum surface wind in a tropical cyclone is reduced by upwards of 5-10% by the induced cooling of the SST.

Given that a tropical cyclone causes cooling of the sea surface, it might be of particular interest to observe the intensity changes of tropical cyclones which stall over water for extended periods of time. A testable hypothesis is that tropical cyclones which remain quasi-stationary over water for extended periods of time weaken (or at best, do not increase in intensity) as the underlying SST falls. Such reasoning has been used operationally in the past by the JTWC to forecast rapid weakening of a tropical cyclone (e.g., Jack 1989). While Verne remained quasi-stationary for seven days within 150 nm (280 km) of 17°N ; 130°E, it intensified from 75 kt to 115 kt (its peak intensity) during the first two days of its stall, it weakened from 115 kt to 105 kt during the next two-day period of its seven-day stall, and then began to lose intensity more rapidly (a 60 kt decrease from 105 kt to 55 kt) during the latter three days. Although Verne weakened significantly during the latter portion of its stall, it is inappropriate to claim that the storm-induced cooling of the SST was the major factor contributing to this weakening. More research is necessary to confirm the role of tropical cyclone induced SST changes upon the tropical cyclone itself.

IV. IMPACT

Verne brought gusty winds and heavy rain to Guam, Rota, Tinian and Saipan. Some minor damage to vegetation was reported on Guam. Reports from Saipan indicated more extensive fallen or uprooted trees. No reports of storm-related injuries or damage to houses or buildings were received. The maximum wind gust measured on Guam was 60 kt (31 m/sec).

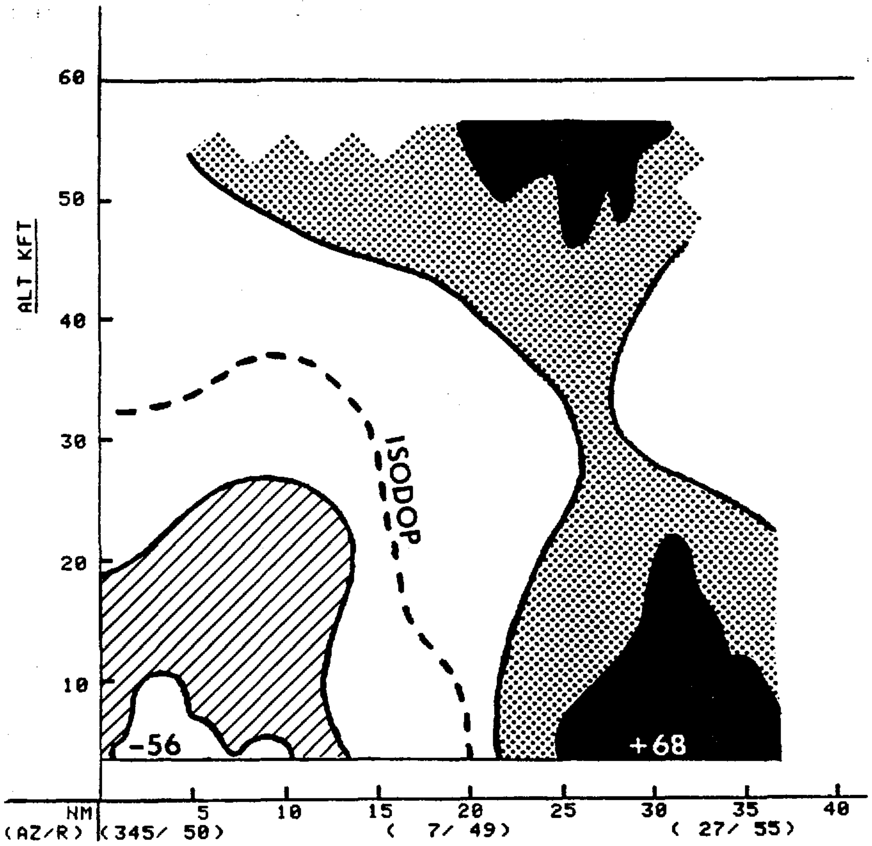


**Figure 3-33-7** East-west cross-section (looking north) cut through the center of Verne shows inbound or outbound velocity with respect to Guam's NEXRAD. The hot tower on the eastern side of Verne's low-level center appears to have carried southerly (outbound) winds aloft resulting in a deepening of Verne's cyclonic circulation (182324Z October NEXRAD velocity cross section).